OVER 60 YEARS OF DIRECT GEOTHERMAL USE AT WAIRAKEI - TAUHARA AND GROWING STRONGER …..

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ABSTRACT

The broader geothermal resources associated with the Wairakei Tauhara Geothermal System have been supporting a range of direct uses for significantly longer than the 60 years that the Wairakei Geothermal Power Station has been operational. The paper explores direct use prior to the Wairakei Power Development and the direct uses that have emerged in conjunction with or through the period of the Wairakei development. The future of direct use is discussed along with activity occurring to foster uptake that the Bay of Connections as a Regional Development Agency is leading.

1. INTRODUCTION

Direct use has been a feature of the Wairakei Tauhara Geothermal System (Figure 1) from since the time of Ngātoroirangi when he was warmed by the basket of glowing embers brought by his sisters Te Hoata and Te Pupu (Severne 1999). Subsequent Māori habitation and occupation in the areas where geothermal flows to the surface at Wairakei and Tauhara have seen the resources provide for Hapu in various ways.

With the development of roads and the ability to travel in the mid to late 1800's the area became more accessible for sightseeing, tourism, bathing and associated treatment of ailments. Various accommodation facilities developed. Much later, in the 1940's, the interest in energy development emerged, investigations were undertaken and large scale energy development for electricity generation occurred at Wairakei. As a consequence of this work opportunities have emerged for direct use of geothermal resources. These have included tourism, bathing, horticulture, aquaculture, and kiln drying of timber.

As the town of Taupō has grown, parts of the town that have geothermal resources present at a relatively shallow depth have been able to utilize these for heating in residential and commercial facilities.

Looking to the future there are many more opportunities that will open up to use directly the geothermal resources that are abundant in the Wairakei Tauhara area.

This paper canvasses the past, the present and the future of direct geothermal use associated with the Wairakei Tauhara Geothermal System.

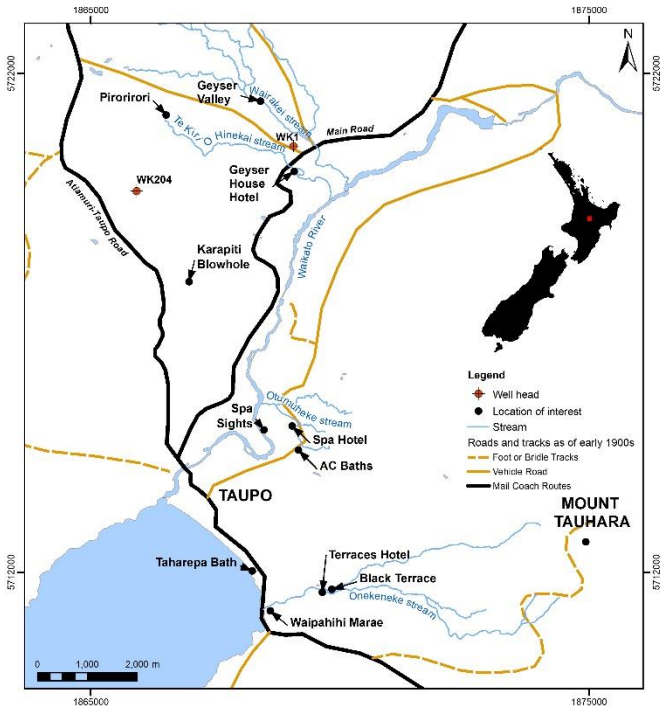


Figure 1: 1900 Location map of Wairakei-Tauhara-Taupō and locations of some places discussed in the paper (Courtesy Samantha Alcaraz GNS Science).

2. GEOTHERMAL DIRECT USE

The earliest recorded uses at Wairakei – Tauhara are of Māori and Hapu using the resources to provide warmth, bathing, healing, places to cook and supplies such as of aruhe (fern root), paruparu (black dye) and kokowai (red ochre).

Te Kiri o Hinekai, Geyser valley, Karapiti, the Otumuheke, the right bank of the Waikato River south of the Otumuheke, the Taupō foreshore south from Taharepa and the Onekeneke valley were locations were geothermal water was readily accessible with geothermal surface features present at some of these locations.

Figure 2: Karapiti ca 1900 (Alexander Turnbull Library)

Allen (1894) records Joshua's Spa in Glen Loffley (at the site of the Spa Hotel, Otumuheke stream, Taupō) as having four or five hot or tepid baths and one cold swimming bath. A 1885 photo of two baths at The Glen run by John Loffley are recorded in Rockel (1986). Tinne (1873) records that at the junction of the Otumuheke stream with the Waikato River there was a smooth rock channel waterfall that you could slide down into the pool below. This area remains very popular today for bathing. (Figure 3).

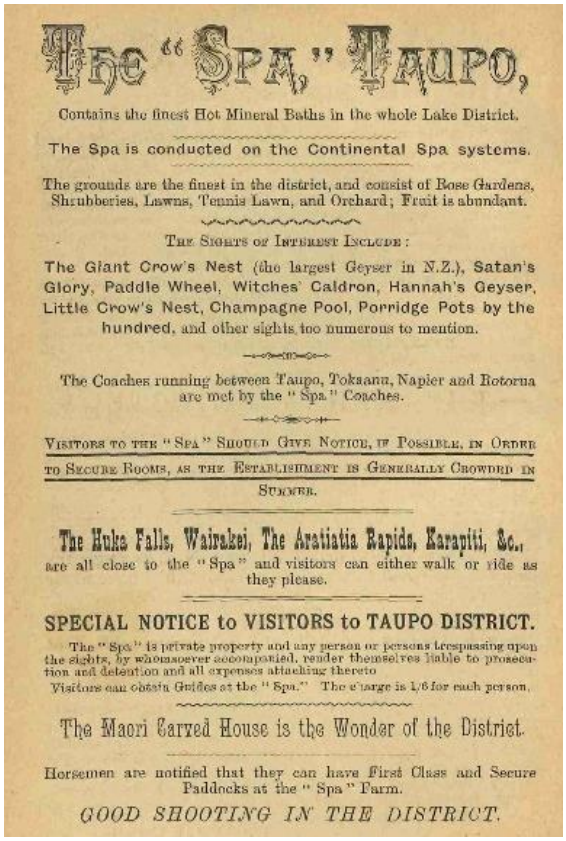
Figure 3: Bathing at the confluence of the Otumuheke and the Waikato River.

Allen (1894) records a pretty pool in the grounds of the Geyser House Hotel and several pools in Te Kiri o Hinekai stream near this Wairakei hotel developed by Robert Graham in 1881. Rockel (1986) records the fairy pool (waterfall), the fountain and the cascade baths in Te Kiri o Hinekai. An advertisement notes that the hot spring had been known and used by Māori for many years. The geothermal activity, Huka Falls, the Aratiatia Rapids and trout fishing were all a part of the offerings from the Geyser House Hotel.

Matarakutia a healing pool ascribed by Tuwharetoa to cure leprosy (Rockel 1986) was located on the left bank of the Waikato River above Huka Falls.

2.1 The Spa Taupō

Figure 4 is an 1894 advertisement for the activities and attractions associated with the Spa Taupō. Some of the geothermal expressions at Spa Sights are specifically named in the advertisement.



The "Spa," Taupo,

Contains the finest Hot Mineral Baths in the whole Lake District.

The Spa is conducted on the Continental Spa systems.

The grounds are the finest in the district, and consist of Rose Gardens, Shrubberies, Lawns, Tennis Lawn, and Orchard; Fruit is abundant.

The Sights of Interest Include:

The Giant Crow's Nest (the largest Geyser in N.Z.), Satan's Glory, Paddle Wheel, Witches' Caldron, Hannah's Geyser, Little Crow's Nest, Champagne Pool, Porridge Pots by the hundred, and other sights too numerous to mention.

The Coaches running between Taupo, Tokaanu, Napier and Rotorua are met by the "Spa" Coaches.

Visitors to the "Spa" Should Give Notice, if Possible, in Order to Secure Rooms, as the Establishment is Generally Crowded in Summer.

The Huka Falls, Wairakei, The Aratiatia Rapids, Karapiti, &c., are all close to the "Spa" and visitors can either walk or ride as they please.

SPECIAL NOTICE to VISITORS to TAUPO DISTRICT.

The "Spa" is private property and any person or persons trespassing upon the sights, by whomsoever accompanied, render themselves liable to prosecution and detention and all expenses attaching thereto

Visitors can obtain Guides at the "Spa." The charge is 1/6 for each person.

The Maori Carved House is the Wonder of the District.

Horsemen are notified that they can have First Class and Secure Paddocks at the "Spa" Farm.

GOOD SHOOTING IN THE DISTRICT.

Figure 4: Spa Taupō Advertisement (Allen 1894)

2.2 AC Baths

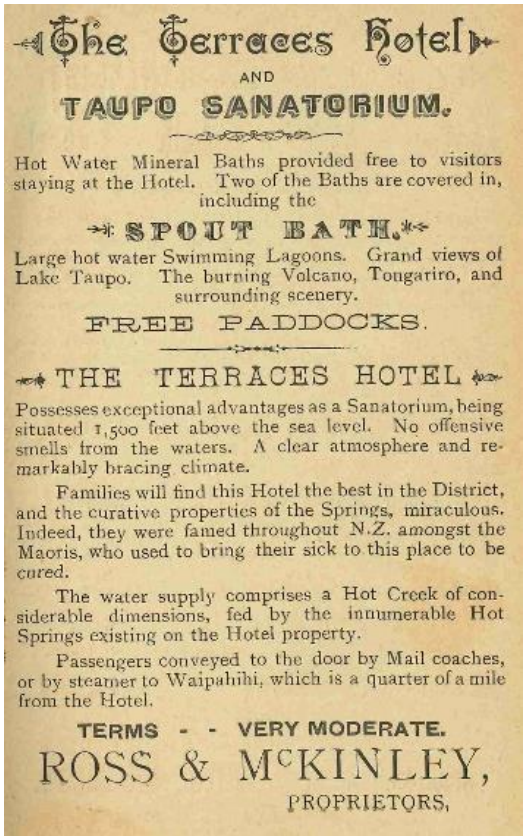
The AC Baths named after the Armed Constabulary, whose soldiers dug the original pool upstream of Lofley's pool, has developed through time into the Taupō District Council run AC Baths facility.

Figure 5: AC Baths 2018

2.3 Terraces - Onekeneke

The Terrace Hotel was built in 1889. In the valley below the hotel were the Black Terrace, a hot lake, several bathing pools, including the Iron Bath, the Douche (spout) Bath and the Sulphur Bath (Cody 1993).

Figure 7: Onekeneke Hot Lake. Mt Tauhara in the background (Allen 1894)



The Terraces Hotel
AND
TAUPO SANATORIUM.

Hot Water Mineral Baths provided free to visitors staying at the Hotel. Two of the Baths are covered in, including the

SPOUT BATH.

Large hot water Swimming Lagoons. Grand views of Lake Taupo. The burning Volcano, Tongariro, and surrounding scenery.

FREE PADDOCKS.

THE TERRACES HOTEL

Possesses exceptional advantages as a Sanatorium, being situated 1,500 feet above the sea level. No offensive smells from the waters. A clear atmosphere and remarkably bracing climate.

Families will find this Hotel the best in the District, and the curative properties of the Springs, miraculous. Indeed, they were famed throughout N.Z. amongst the Maoris, who used to bring their sick to this place to be cured.

The water supply comprises a Hot Creek of considerable dimensions, fed by the innumerable Hot Springs existing on the Hotel property.

Passengers conveyed to the door by Mail coaches, or by steamer to Waipahihi, which is a quarter of a mile from the Hotel.

TERMS - - VERY MODERATE.

ROSS & McKINLEY,
PROPRIETORS.

Figure 7: Terraces Taupō Advertisement (Allen 1894)

The Terraces Hotel was renamed Debretts Thermal Hotel in 1964 and the thermal baths have changed and developed into what we know today as the Taupō DeBretts Spa Resort. The facilities offer hot thermal outdoor pools and indoor private pools, cold freshwater pools, water play facilities, and offerings of body treatment and massage.

2.4 Wairakei Resort Hotel

During the late 1940's and through into the 1950's geothermal investigation drilling at Wairakei identified a significant heat resource. One of the very earliest wells WK1, drilled in May 1950, was used to supply steam for direct heat use at the Wairakei Resort Hotel.

Figure 8: Wellhead of WK1

The well was drilled to a depth of 183m (600ft), and had a wellhead pressure of 14 bar (200psi). The well ceased to supply the hotel in the late 1950's at which point steam was supplied to the hotel from one of the steam pipelines feeding the Wairakei Power Station. The well was cemented up in April 1962.

Today geothermal steam is used in the hotel to supply heat to the buildings, to heat two swimming pools, and outdoor hot tubs. In earlier times it was used in the hotel kitchen (Figure 9).

Figure 9: Wairakei hotel kitchen steamer - 1957.

The Wairakei Power Plant was commissioned from November 1958 through into 1963 and a new focus emerged for the hotel with the pioneering geothermal development becoming a feature of visits and tours from the hotel.

An incident associated with the drilling of WK 204 in 1960 saw the creation of what became known as the "Rogue Bore". Between 1968 and 1973 tourist visits were organized to this spectacle, where the ground shuddered under your feet.

Figure 10: WK 204 in 1969. (Bolton et al 2009)

2.5 Aquaculture – Tourism - Huka Prawn Farm.

The Prawn Farm was developed in 1987 by Aquatech Farms Ltd. The farm imported breeding stock of Macrobrachium Rosenbergii (Giant Malaysian River Prawn) into New Zealand and developed the operation around breeding and rearing prawns for sale. By December 1988 there were about 150,000 prawns growing in the outside ponds (NZ Aquaculture 2005). Initially the farm used hot water taken from the Wairakei stream as a source of heat to raise the temperature of the freshwater circulating through the rearing ponds. The farm enlarged adding 9 outdoor rearing ponds in 2002. As the Wairakei Power Station moved to injecting more geothermal water the heat available from the Wairakei Stream decreased and the Pawn Farm moved to using heat taken from the injection water pipeline.

Figure 11 Huka Prawn Park

A tourism focus around the prawn operation developed with the rebranded Huka Prawn Park. Some 75,000 visits per year are made to Huka Prawn Park to tour the hatchery and rearing ponds, or fish for prawns in the outdoor ponds, or paddle boats or boards, or enjoy a meal in the restaurant.

2.6 Wairakei Terraces

This development started in the year 2000 using water supplied from the Wairakei Geothermal Power station injection line. The banks of Te Kiri o Hinekai stream were revitalized, walks established, the Honeymoon pool (Avenue bath) was dug out, a geyser and silica terraces along with bathing pools were developed. The terraces have become coated in silica from the geothermal water cooling as it flows over them. Bathing pools have become popular for soaking and soothing the body in the silica rich geothermal water. About 90,000 visitors per year visit the Wairakei Terraces

Figure 12: Wairakei Terraces pools.

2.7 Other Wairakei Ventures.

The Wairakei Steamfield lookout is a top rated (tripadvisor), free to access, visitor sight during daylight hours. Wairakei Thermal Valley has tea rooms, camping sites and walks up through the old Geyser Valley. Heli Adventure Flights offers helicopter rides over the Wairakei Geothermal Steamfield as a part of one of their scenic flights. Karapiti thermal area is managed by the Craters of the Moon Trust (www.cratersofthemoon.co.nz) which offers low cost admission to board walks in the Karapiti Thermal area. Proceeds from the trust are distributed into the local Taupō Community.

2.8 Novel Direct Geothermal Heat uses at Wairakei

2.8.1 Karapiti Thermal Area Kiosk

The eco-friendly visitor kiosk at the Karapiti Thermal Area is heated with geothermal heat captured from a heat exchanger buried in hot ground that supplies heat to hydronic floor loops in the kiosk facility. There is a small pump that moves the water through the system, with the electricity provided by a solar photovoltaic installation.

Figure 13 In slab hydronic piping at the Karapiti Kiosk (Photo courtesy Laser Plumbing Taupō)

2.8.2 Wairakei International Golf Course

The Wairakei International Golf course uses a manmade lake, that is also a water hazard on the golf course, as a source of heat energy for a 20 kW heat pump system that conditions 350 m^2 of facility space in the club house. There are coils of polyethelyene pipe submerged in the water hazard that supply energy to the water to water heat pump that supplies energy to the hydronic floor coils in the club house. This is the only example of a geothermal heat pump known to be in operation in the vicinity of Wairakei. A GNS Science case

study (GNS Science 2016, GHP – Wairakei Golf) features this geothermal heat pump installation.

2.8 Native Plant Nursery.

A small geothermal steam supply to the Lands and Survey Nursery from well TH2 in Tauhara was established to deliver heat for the nursery to assist with plant rearing and propagation, particularly during the colder months. A small separator was installed on the TH2 well site with a steam line crossing the Lands and Survey farm to the nursery. The Department of Conservation continued operating the steam supply when they took over the nursery operation in the 1980's. In the 1990s the facility moved into private ownership, then becoming known as the Taupō Native Plant Nursery supplying to the public. In 2007 Contact changed the energy feed to the nursery to come from the Tenon heat supply system, which then was using TH2 as one of the producing wells supplying the heat plant (see below).

2.9 Tenon

The Tenon Taupō timber facility is a significant employer in the Taupō area employing some 265 staff. In 2006 the facility transitioned from natural gas fired boilers and direct fired timber drying kilns to geothermal energy drying the timber. The work was reported in Dobbie and Moore (2011). The three two-phase geothermal heat exchangers that make up the heat plant are shown in Figure 14. Two heat exchangers (HX 1 and 2) supply 180 ^{o}C fluid and HX 3, 150 ^{o}C fluid.

Figure 14: Tenon Two Phase Geothermal Heat Plant.

In transitioning to geothermal energy Tenon reduced its CO_2 emissions by about 28,000 tonnes per year, reduced operating costs by NZD 1.2 Million per year and increased the capacity to dry timber by 5% (Taupō Times 2007).

2.11 Taupō Hospital.

In 2010 the Taupō Hospital transitioned from coal fired boilers to a geothermal energy supply. Geothermal fluid at 100 ^{o}C is pumped from a 220m deep well, supplied to the hospital heat plant heat exchangers and then returned underground at 80 ^{o}C. The downhole submersible pump at maximum flow supplies a peak of about 400kW of heat, at minimum about 100 kW and the average heat use over a year is about 200kW (Febrianto et al 2013). The move to geothermal energy reduced the greenhouse gas emissions from the hospital by about 700 tonne CO_2 e/yr. (Thain 2011)

2.12 Clean Energy Centre Taupō

A geothermal system using energy extracted from a bore on the site reticulates heat to hydronic circuits installed in the floor of the building. The ground floor is made of concrete mixed locally with fly ash from Huntly Power Station which was used to replace some of the cement. NZ timber has been used extensively with the frond-shaped atrium laminated timber portals made from sawmill off-cuts. The facility is in private ownership.

Figure 15: Atrium Clean Energy Centre Taupō.

2.13 Greenhouses

There have been two commercial horticultural ventures using geothermal energy to assist with production.

Geotherm Exports grew phalaenopsis orchids in greenhouses on the corner of Poihipi Road and Tukairangi Road from 1981 until about 2006. 250,000 orchid plants were grown in the 8100 m^2 of greenhouse set up to mimic the tropical environment in which the orchids thrive. The heat was supplied from geothermal energy, with about 700 kW required at times of peak heat demand in winter (Koorey 1996)

A commercial greenhouse growing lilies was established in Tauhara on a terrace north of Stag Park and West of Crown Road. This facility is no longer operating.

2.14 Commercial and residential geothermal heat use in Taupō.

Numerous shallow bores in Taupō, in the Tauhara area, tap into a shallow geothermal resource that is used to provide space and water heating for; private dwellings, commercial / industrial properties, and accommodation facilities.

In the area around Miro and Manuka street concrete floor slabs are naturally heated by the warm ground from below, providing year round heating to the facilities above.

Figure 16: Motel Thermal Pool

Taupō motels and hotels utilize the shallow geothermal resource to provide heating to their facilities and water for private thermal pools for guests' enjoyment. The energy for the pools is provided from a technology mix of discharging wells, pumped wells and wells with downhole heat exchangers.

Residential use can involve: hot water extracted from wells, energy extracted using a downhole heat exchanger that is placed into a well (GNS Science 2016, Home Heating - Taupō) or in the Invergarry Road / Arthur Crescent area, a heat exchanger placed in a shallow steam filled soak hole (Koorey 1996).

3. RECENT ACTIVITY

The Bay of Connections (BoC) and Contact Energy both consider that much more can be done directly with the geothermal resources of the Wairakei Tauhara Geothermal System. There are opportunities for increasing the economic wealth and social wellbeing in the Taupō District, along with potential business investment opportunities for Hapu. Enterprise Great Lake Taupō has in recent times also been working on leveraging the geothermal assets of the Taupō District seeking to develop opportunities that will augment District wellbeing. The approach, along with a Medium Density Fibreboard example, are detailed in Climo et al (2017).

Both BoC and Contact have allocated resources to focus on fostering new geothermal opportunities. In December 2017, a Geothermal Business Development Lead, funded by MBIE, BoC and industry, was contracted to BoC for a period of two years to accelerate the uptake of new businesses establishing using geothermal resources (Daily Post 2018).

In 2015 a dedicated Project Manager was appointed to drive Contact's efforts to promote geothermal direct use, working closely with Contact's industrial sales team, the Bay of Connections, the New Zealand Geothermal Association Geoheat Action Group, Enterprise Great Lake Taupō, and various government agencies.

Contact has been working on a number of projects including timber processing and aquaculture. Contact reflects that it is interesting to observe that the availability of resources other than the availability of geothermal water or energy has impeded some of the projects from establishing. Hurdles identified are project specific and include market access, investment capital, access to freshwater, regulatory hurdles and logistics.

4. THE FUTURE

While all regions can leverage New Zealand's' national brand attributes, each area must identify and leverage local strengths that differentiate. The Taupō District's strengths are in agriculture, forestry, wood products, geothermal energy, and tourism (Climo, 2017).

An example of a differentiator is the co-location of plantation forestry and the geothermal resources in the Taupō Volcanic Zone (TVZ) as shown in the Bay of Connections plan in Figure 17.

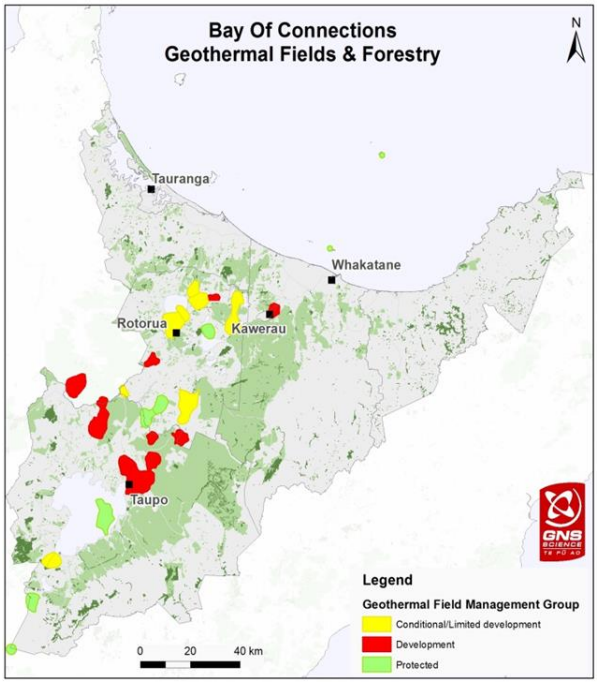


Figure 17: Co-location of plantation forestry and geothermal resources in the TVZ.

In particular the Wairakei Tauhara Geothermal system, the focus of this paper, sits to the north west of large areas of plantation forest in the southern part of the TVZ.

Tourism is a key sector for New Zealand; it is a fast foreign exchange earner that is growing rapidly; it is also labour-intensive and diverse. The visitor number annual compound growth rate since 2013 is about 8%. Visitor spend over the same period has grown at a compound rate of about 14% per annum (MBIE 2018). International visitor arrivals are predicted to reach 4.9 million by 2023. This is a 39% increase from 3.5 million visitors who came to New Zealand in 2016 (MBIE, 2017a).

In 2017, the central North Island's geothermal/volcanic region hosted 17% of total visitor nights in the country, and 29% of the North Island's visitor nights (MBIE, 2017b).

Tourists are attracted to the globally unique volcanic and geothermal environments which offer a range of experiences; landscapes, parks, walks, geological intrigue, culture, health and wellness, industrial interest and adventure. While New Zealand already has a successful

geothermal tourism industry, the growth of this sector and visitor experiences can be significantly enhanced.

The potential impact of tourism goes beyond the experiences a visitor has in New Zealand. The top six tourist market countries are also in the top ten export market countries for New Zealand commodities. Tourism offers brand and product exposure opportunities, in New Zealand, to our export markets.

Food and Beverage is another important sector with this sector being New Zealand's largest exporter for the last 100 years (MBIE, 2010). New Zealand's clean, green branding and access to renewable energy for food production is offering competitive advantage in the global marketplace.

Currently businesses which use geothermal in the commercial production of food and beverages are:

- Miraka (Mokai) – Longlife UHT, milk powder, Whaiora (smoothie)
- Gourmet Mokai – Tomato, capsicums
- Arataki (Waiotapu) – Honey processing
- Huka Prawn Park (Wairakei) – Prawn rearing

Only one of the food and beverage businesses listed above uses heat from the Wairakei Tauhara Geothermal System. The application of geothermal technologies to food and beverage production in New Zealand is a significant opportunity. What potential is there for other food and beverage businesses to establish and benefit from the renewable energy credentials that Wairakei Tauhara geothermal offers?

4. GROWING THE FUTURE ….

Geothermal resources are an enabler of economic growth through a range of opportunities that can be developed in the years ahead. Branding credentials will accrue to businesses that use geothermal in their operations.

Enterprise Great Lake Taupō and the Bay of Connections (BoC) are interested in fostering prosperity, jobs and economic wellbeing. The strengths of the Taupo District become a natural focus for further development in embellishing District economic wellbeing.

Contact Energy is interested in growing the use of geothermal at Wairakei and Tauhara and in so doing growing the Taupō community. This will see more diversity, with different businesses establishing using geothermal resources in the future. Contact is actively seeking businesses interested in geothermal at Wairakei-Tauhara and Craig Stephenson, the Contact author on this paper, is the person to connect with to explore the opportunity for your business.

If you are interested in direct use geothermal in the broader Bay of Plenty area Andrea Blair is well connected into the Bay of Connections work.

And there will, without a doubt, be more and more direct use geothermal …..

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